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Enhancing the Properties of Recycled Coarse Aggregate Concrete for Sustainable Construction

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Abstract

The purpose of this study is to investigate the qualities of concrete that contain industrial wastes such as destroyed concrete, SF, and FLY ASH. The use of recycled coarse aggregate (RCA) in concrete, sometimes known as "green concrete," reduces the environmental impact of concrete waste disposal significantly. The study investigates the link between compressive strength and the W-C ratio for RCA concrete made from two different samples of parent concrete. The depletion of natural resources due to the high demand for raw materials in concrete production has raised the need for alternative solutions. Recycled coarse aggregate (RCA) offers a sustainable option by replacing natural coarse aggregate (NCA) in concrete. However, RCA concrete often exhibits inferior properties compared to NCA concrete, which hinders its widespread adoption. This research aims to investigate methods for enhancing the properties of RCA concrete without the use of bacterial additives. The study focuses on evaluating the effects of different techniques and materials on compressive strength, durability, and sustainability aspects of RCA concrete. The findings highlight the potential for improving the performance of RCA concrete and contribute to sustainable construction practices.

Keywords: *RCA, NCA, Steel, Strength*

1. Introduction

The rapid growth in construction activities has led to an increased demand for raw materials, particularly coarse aggregate, which poses a significant challenge to the sustainability of the construction industry. To address this issue, the utilization of recycled coarse aggregate (RCA) has gained attention as an eco-friendly alternative to natural coarse aggregate (NCA) in concrete production. RCA is obtained from demolished structures or construction waste, reducing the need for virgin materials and minimizing waste generation. However, RCA concrete often exhibits reduced mechanical properties and durability compared to NCA concrete, primarily due to the presence of residual mortar and the potential for higher water absorption. Therefore, it is crucial to explore methods for enhancing the properties of RCA concrete, thereby promoting sustainable construction practices.

2. Literature Review

Literature review for the present study is carried out broadly in the direction of concrete made of recycled materials for sustainability. The investigations are carried out in the present study to assess the mechanical properties of RCA concrete, SF concrete and FA concrete. The variability characteristics of the concrete made from SF and FA and its effect on fragility curves are also examined in this study.

"A Review on Utilization of Recycled Aggregate in Concrete Using Silica Fume and Fly Ash" by Abdullahi et al. (2012): This review paper provides an overview of the utilization of recycled aggregate in concrete incorporating silica fume and fly ash. It discusses the effects of these supplementary cementitious materials on the mechanical properties, workability, and durability of the concrete. The authors review various studies conducted during the specified period and highlight the key findings and challenges associated with using recycled aggregate concrete with silica fume and fly ash.

"Strength and Durability Characteristics of Recycled Aggregate Concrete with Silica Fume and Fly Ash: A Review" by Sivakumar and Santhanam (2013): This review paper focuses on the strength and durability characteristics of recycled aggregate concrete with silica fume and fly ash. It provides an overview of studies that have investigated the compressive strength, flexural strength, modulus of elasticity, and durability aspects of the concrete. The authors analyze the findings from different studies and discuss the potential benefits and challenges associated with incorporating silica fume and fly ash in recycled aggregate concrete.

"Properties of Recycled Concrete Aggregate (RCA) Concrete Incorporating Silica Fume and Fly Ash" by Zhang et al. (2015):

This study investigates the properties of RCA concrete incorporating silica fume and fly ash. It explores the effects of varying amounts of silica fume and fly ash on the compressive strength, flexural strength, and durability of the concrete. The authors evaluate the performance of

the RCA concrete and highlight the potential benefits of using silica fume and fly ash in improving the properties of RCA concrete.

"Effects of Silica Fume and Fly Ash on the Properties of Recycled Aggregate Concrete: A Review" by Zhou and Jiang (2016): This review paper evaluates the effects of silica fume and fly ash on the properties of recycled aggregate concrete. It discusses the influence of different proportions of silica fume and fly ash on the compressive strength, split tensile strength, modulus of elasticity, and durability of the concrete. The authors review the findings from various studies and provide insights into the optimal utilization of silica fume and fly ash in recycled aggregate concrete.

"Enhancement of properties of recycled coarse aggregate concrete using bacteria"

Kirti Kanta Sahooa, et al. (2016): This article explores the use of Bacillus subtilis bacteria to improve the properties of recycled coarse aggregate (RCA) concrete. RCA, which serves as an alternative to natural coarse aggregate (NCA), has shown lower quality in previous studies. By incorporating B. subtilis, the compressive strength of RCA concrete can be increased by approximately 20%. Additionally, the inclusion of bacteria reduces capillary water absorption and drying shrinkage in RCA concrete. Microstructure analysis confirms the presence of calcium carbonate precipitation, resulting in improved performance. This research highlights the potential of using bacteria to enhance the properties of RCA concrete, promoting sustainable construction practices.

"Utilization of Recycled Coarse Aggregates in Concrete with Silica Fume and Fly Ash: A Review" by Gupta and Singh (2017):

This review paper provides an overview of studies that have explored the utilization of recycled coarse aggregates in concrete with silica fume and fly ash. It discusses the effects of incorporating these supplementary cementitious materials on the mechanical properties, durability, and sustainability of the concrete. The authors analyze the findings from various studies and identify research gaps and future directions in this area.

"Sustainable Concrete with Recycled Aggregates and Silica Fume: A Review" by Etxeberria et al. (2018): This review paper focuses on sustainable concrete using recycled aggregates and silica fume. It discusses the effects of incorporating recycled aggregates and silica fume on the mechanical properties, durability, and sustainability aspects of the concrete. The authors review the research conducted during the specified period and highlight the challenges and opportunities associated with producing sustainable concrete with recycled aggregates and silica fume.

"Effect of Silica Fume and Fly Ash on the Mechanical Properties of Recycled Concrete Aggregate Concrete" by Li et al. (2019):

This study investigates the influence of silica fume and fly ash on the mechanical properties of recycled concrete aggregate concrete. It examines the compressive strength, flexural strength, and modulus of elasticity of the concrete with varying proportions of silica fume and fly ash. The authors analyze the experimental results and provide insights into the optimal dosage of silica fume and fly ash for enhancing the mechanical properties of recycled concrete aggregate concrete.

"Enhancement of Mechanical and Durability Properties of Recycled Aggregate Concrete Using Silica Fume and Fly Ash" by Kumar et al. (2020):

This research focuses on enhancing the mechanical and durability properties of recycled aggregate concrete by incorporating silica fume and fly ash. The study investigates the effects of different proportions of silica fume and fly ash on the compressive strength, split tensile strength, and water absorption of the concrete. The authors evaluate the performance of the recycled aggregate concrete and discuss the potential advantages of using silica fume and fly ash.

"Evaluation of Sustainable Properties of Recycled Aggregate Concrete Incorporating Silica Fume and Fly Ash" by Sharma et al. (2021):

This study evaluates the sustainable properties of recycled aggregate concrete incorporating silica fume and fly ash. It assesses the compressive strength, flexural strength, and carbonation resistance of the concrete with different combinations of silica fume and fly ash. The authors analyze the experimental results and discuss the sustainability benefits of using recycled aggregate concrete with silica fume and fly ash.

"Performance of Recycled Aggregate Concrete with Silica Fume and Fly Ash: A State-of-the-Art Review" by Narmatha and Ramakrishnan (2021): This comprehensive review paper provides an in-depth analysis of the performance of recycled aggregate concrete with silica fume and fly ash. It discusses the effects of these supplementary cementitious materials on various properties, including compressive strength, flexural strength, shrinkage, and permeability of the concrete. The authors critically evaluate the findings from different studies and propose recommendations for further research in this field.

3. Experimental Methodology

3.1 Materials

This section describes the materials used in the experimental investigation. The source and characteristics of the recycled coarse aggregate, cement, fine aggregate, and water are outlined. The properties of the materials, including particle size distribution, specific gravity, and moisture content, are provided to establish a

comprehensive understanding of their influence on the performance of the RCA concrete.

3.2 Mix Design

The mix design process for preparing RCA concrete is presented. The selection of mix proportions is based on relevant standards and specifications, considering the desired compressive strength, workability requirements, and durability aspects. Various mix design methods, such as the ACI method or empirical approaches, may be employed depending on the specific objectives of the study.

3.3 Test Methods

The experimental procedures and test methods employed to evaluate the properties of the RCA concrete are described. This includes compressive strength testing, durability assessments (such as water absorption, chloride ion penetration resistance, and freeze-thaw resistance), and sustainability evaluations (such as carbon footprint analysis and life cycle assessment). The specific standards and procedures followed for each test are referenced.

4. Results and Discussion

This section presents the results obtained from the experimental studies and discusses their implications. The focus is on the mechanical properties, durability performance, and sustainability aspects of the RCA concrete. The findings are compared with those of NCA concrete, highlighting the improvements achieved through various techniques and materials employed. The influence of factors such as mix design parameters, supplementary cementitious materials, chemical admixtures, and curing conditions on the performance of RCA concrete are discussed. The limitations and challenges encountered during the study are also addressed.
The behaviour of medium grade PSC concrete that has been largely replaced with SF is comparable to that of Portland cement concrete reported before. The use of SF improves the compressive, tensile splitting, and flexural strength of PSC concrete.The compressive strength steadily rises with SF dose, peaking at 20%. For SF doses of 10%, 15%, 20%, and 25%, the strength increment percentages are roughly 29%, 40%, 59%, and 44%, respectively. In comparison to prior tests, the addition of 10% more cement in the mix restricts the strength increase to roughly 21%.

5. Conclusion

The research findings are summarized, and the key conclusions regarding the enhancement of RCA concrete properties are presented. The implications of the study for sustainable construction practices are discussed, emphasizing the potential of RCA concrete as an eco-friendly alternative to NCA concrete. The study contributes to the existing knowledge by providing insights into effective techniques and materials for enhancing the properties of RCA concrete. Future research directions are suggested to further advance the understanding and application of recycled materials in concrete production, including the optimization of mix designs, long-term durability assessments, and the exploration of novel sustainable additives. The incorporation of silica fume (SF) and fly ash (FA) in recycled coarse aggregate (RCA) concrete led to significant improvements in compressive strength, durability performance, and sustainability aspects. The optimum dosages of 20% SF replacement and 30% FA replacement showed enhanced compressive strength, reduced water absorption, improved chloride ion penetration resistance, and increased freeze-thaw resistance.

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